On Optical (Y,Gd)AG:Pr Ceramics

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International Symposium on Ceramic Materials and Components for Energy and Environmental Applications
10th CMCEE
May 20-23, 2012
Dresden, Germany

Luminescent inorganic materials doped by trivalent lanthanide ions as e. g. Pr^{3+} are applied in detectors and x-ray films to convert x- and gamma-rays to near UV or visible radiation. These converters, also called scintillators, shall exhibit a short decay time, which can be enabled by Pr^{3+} doped materials.

This presentation deals with solid solutions of yttrium aluminium and yttrium gadolinium garnet doped by Pr^{3+}, i.e. with powder compositions according to the formula $(Y_{1-x}Gd_x)_3Al_5O_{12}$:Pr and their processing towards translucent or eventually transparent ceramics. The preparation and characterisation of translucent ceramics of (Y,Gd)AG:Pr will be presented.

Powder Preparation, Ceramic Fabrication and Reflection Spectra of YAG:Pr^{3+} and YAG:Gd^{3+},Pr^{3+}

Dissolving of Y_2O_3, Al_2O_3, Gd_2O_3, and $Pr(NO_3)_3*6H_2O$ in nitric acid

↓

Adding trisamine as a fuel to the solution

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Slow evaporation, while at the end of the evaporation combustion process ignites

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Ball milling of combustion residue yields black precursor

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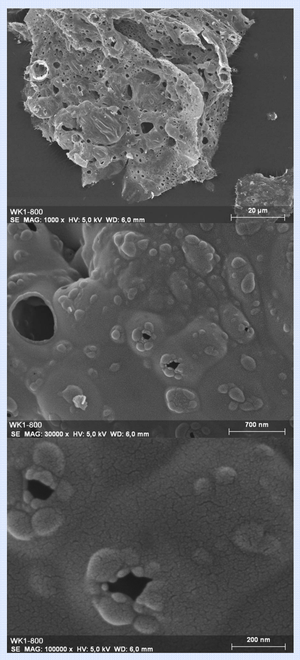
Calcining the black precursor at 800 – 1000 °C for 2 h in air



SEM images of calcined agglomerated precursor (YAG doped by 1% Pr)

Ball milling of white powder* YAG:Pr in Ethanol

↓

Uniaxial pressing, 30 MPa without additivea

↓

Cold isostatic pressing, 300 MPa

↓

Free sintering at 1650 °C, 4 h, air on Al_2O_3 substrate

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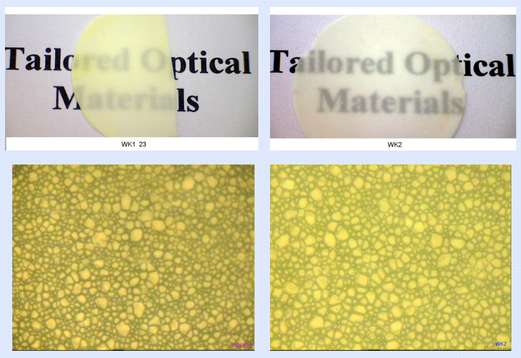
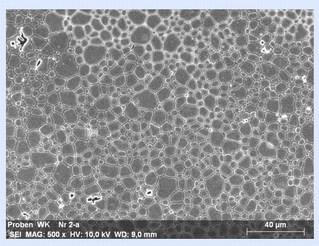
Polishing and thermal treatment at 1600 °C, 1 h, air

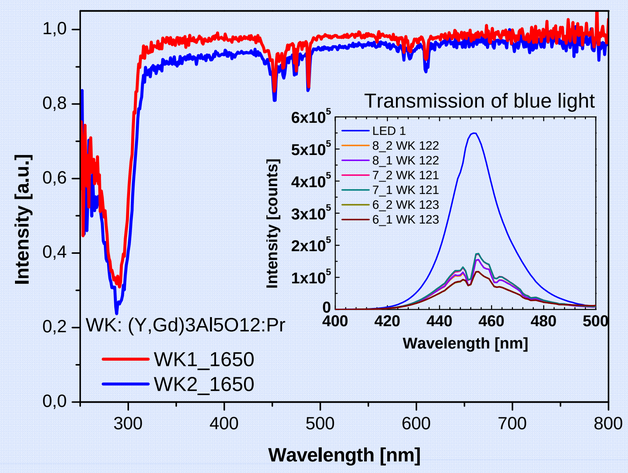


Images of ceramics of YAG:Pr and YAG:Gd,Pr, (Thickness 0,3 mm)



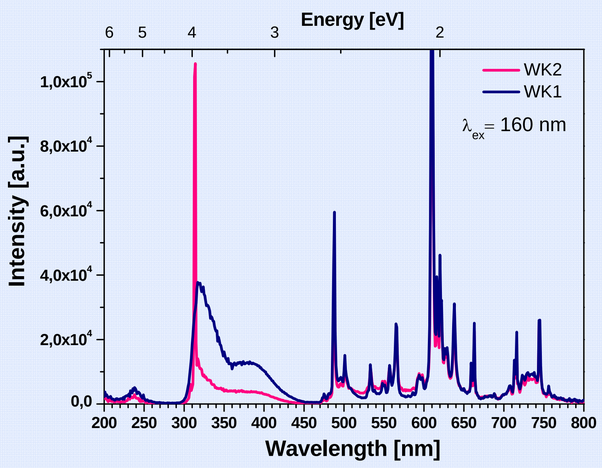
SEM images of YAG:Pr ceramic

Excitation 395 nm

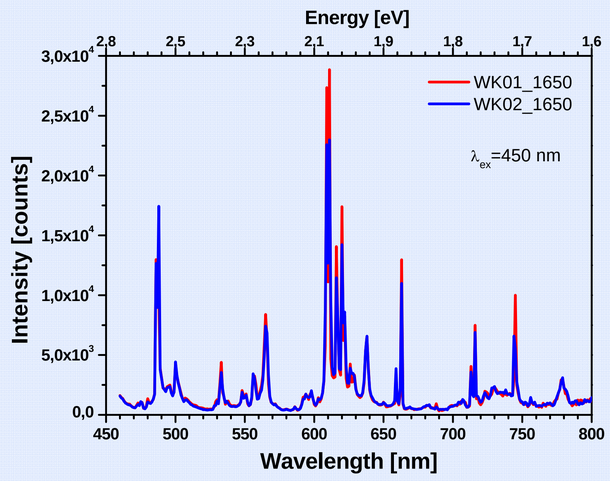


Reflection spectra of YAG:Pr (WK1) and YAG:Gd:Pr (WK2)

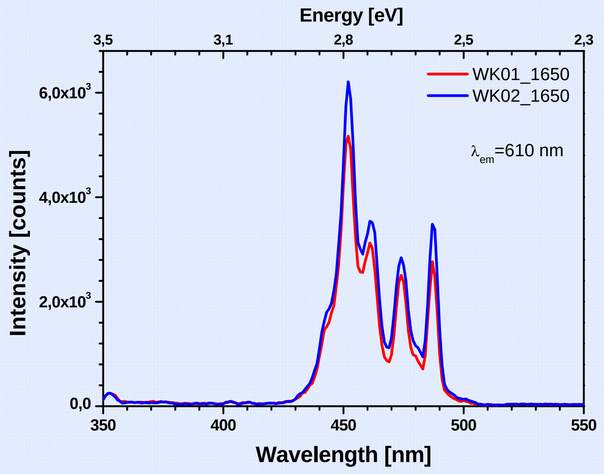
Luminescence Spectroscopy of Yttrium Aluminium Garnet Ceramics YAG:Pr^{3+} (1%) and YAG:Pr^{3+}(1%)Gd^{3+}(10%)



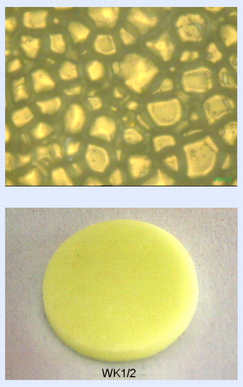
Emission spectra upon160 nm excitation



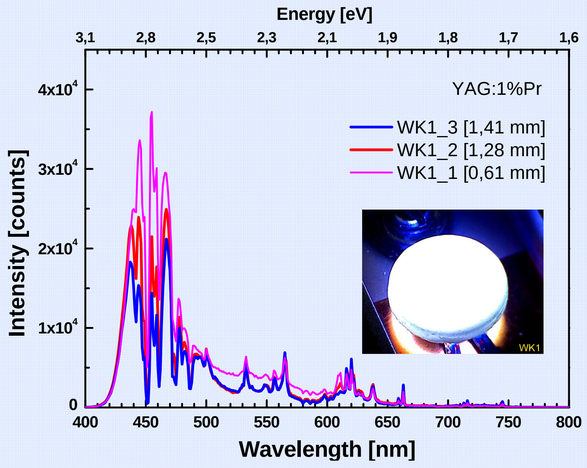
Emission spectra upon 450 nm excitation

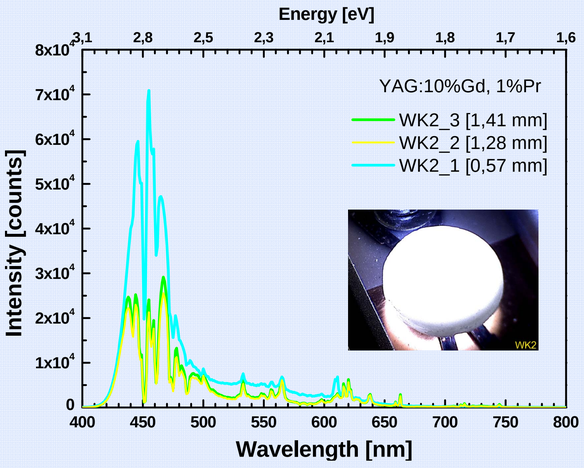


Excitation spectra monitored for 610 nm emission

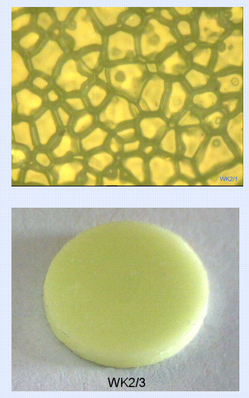


Microstructure and Image of ceramics YAG:Pr (sintering 1650 and 1700 °C for 12h)





Images of the ceramics and their emission spectra in transmission upon 450 nm exc.



Microstructure and Image of ceramics YAG:Gd,Pr (sintering 1650 and 1700 °C for 12h)

Conclusions and Outlook

The morphological and optical properties of YAG:Pr and YAG:Pr,Gd ceramics were determined by optical and secondary electron microscopy as well as by reflection and luminescence spectroscopy. Fluorescence spectra show excitation bands at 320 and 378 nm for YAG:Pr and 315 nm for YAG:Pr,Gd due to the interconfigurational 4f-5d transition of the Pr^{3+}. The excitation spectra are dominated by the Pr^{3+} ion, whereas the influence of Gd^{3+} is relatively weak. The emission spectra show 4f5d emission in the UV range and 4f-4f emission in the visible range, while the incorporation of Gd^{3+} quenches the 4f-5d emission. At the same time 4f4f emission of Gd^{3+} at 311 nm shows up.

The transmission spectrum of translucent ceramics of YAG:Pr and YAG:Gd,Pr upon blue light excitation shows that part of the blue radiation is converted into red light due to the $^3H_4$ – ^3P_J transitions of Pr^{3+}. Measurements of the conversion efficiency upon x-ray excitation are under way.